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FACULTY WORKING  
PAPER NO. 749

**Wage-Risk Premiums and Workmen's Compensation:  
A Refinement of Estimates of Compensating  
Wage-Differential**

*Richard J. Arnould  
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Wage-Risk Premiums and Workmen's Compensation:  
A Refinement of Estimates of Compensating Wage-Differential

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## Abstract

Current thought is that the most appropriate method for determining the value of life or of reduced risk of injury is through estimation of a revealed market value individuals place on risk. That theory assumes that risk is transacted in the market in the form of wage premiums workers receive for engaging in higher risk jobs. Hedonic price estimation techniques have been used to estimate that premium. We argue in this paper that the value of life derived from estimates of wage-risk premiums are biased upward because they fail to account for various forms of insurance. Taking into account only one such form of insurance, workmen's compensation, leads to reductions in estimates of value of life of from 23 to 27 percent.



## WAGE-RISK PREMIUMS AND WORKMEN'S COMPENSATION

### I. Introduction

Thaler and Rosen were the first to apply hedonic price estimation techniques to the problem of estimating the value of risk [7]. That effort was the first major breakthrough in the determination of value of life since the development of the traditional methods of estimating the discounted stream of future earnings foregone or the discounted value of the net of earnings over consumption because of death or injury. The Thaler-Rosen method assumes that risk can be transacted in the market; the price at which a unit of risk is sold is the wage premium an individual would be willing to forego to engage in an occupation in which the probability of death or severe injury was reduced by some measurable amount. Also, their method assumes that the value of risk reduction is transferable across experiences.

More specifically, the value of numerous aspects of a job are embedded in the wage rate. One of those dimensions is job related risk. Assume all dimensions are in equilibrium except risk. Then if workers have different attitudes toward risk, a series of indifference curves are generated, the envelope of which defines the minimum trade-off of an individual with certain preferences between risk and wages. In fact, the values on the envelope curve could be thought of as the compensation that must be paid to the marginal worker to get him or her to accept a job with that risk level.

Similarly, for firms there exists a willingness to pay for risk. Again assume that all job characteristics other than risk are in equilibrium. The willingness of a firm to trade risk for profits defines

an isoprofit function for that firm. This may be thought of as the firm's willingness to invest in safety, i.e., items that will reduce the probability of injury or death. The profit maximizing firm will not invest in safety unless each dollar invested results in a direct reduction in wages, thereby providing the ability to measure the wage-risk tradeoff on the firm's isoquants. The isoquants differ among firms due to different safety production functions across industries. The envelope curve of the isoquants reflects the market offer curve.

Appropriate concavity conditions for the isoquants and convexity conditions for the indifference curves will guarantee the existence of a unique set of tangencies. The locus of those tangencies between consumers' indifference curves and producers isoquants are the observed phenomena that have been estimated in a number of studies. The value of the risk coefficient, which measures, e.g., the amount of wages willingly foregone to reduce the risk of death or injury by 1 chance in 10,000, can be extrapolated to determine the implied value of life. Various studies using differing samples, risk estimates, and occupational mixes have provided estimates in two rather distinct ranges [5].

The previous estimates of the value of life or injury explicitly ignore various forms of insurance, including workmen's compensation, that should have the effect of reducing the wage compensation necessary to induce an individual to enter a risky occupation [1]. Thus these studies have overestimated the true market value placed on risk. In this paper we provide a theoretical basis for the inclusion of insurance in the estimation of risk premiums and then estimate the effect of one form of insurance, namely workmen's compensation, on those premiums.<sup>1</sup>

## II. Model of Worker Choice

Assume there are two possible states of the world, injury and no injury. The worker's utility from the composite good  $X$  is contingent on the prevailing state of the world. Other things equal, the worker prefers the state of no injury, i.e.,  $U(X) > B(X)$  for any given  $X$ , where the utility function is  $U$  in the no injury state and  $B$  in the injury state. Each utility function exhibits diminishing marginal utility ( $U'' < 0$ ,  $B'' < 0$ ).

The composite good may be purchased with income earned from working,  $W(p)$ , where  $p$  is the probability of injury associated with each job. A unique  $W(p)$  locus of market opportunities for each worker is determined by the worker's productivity, attitude toward injury, and the firm's technological ability to reduce risk. The  $W(p)$  function is a generalization of Adam Smith's equalizing differences concept. It is an equilibrating device for matching worker preferences over risk and income with employers' willingness to compensate workers for taking risk.

Now introduce into the system insurance in the form of workmen's compensation that is designed to provide recovery of a statutorily determined percentage,  $s$ , of income lost due to job related injuries. Income that may be spent on the composite good if injury occurs is  $sW(p)$ . For convenience, define the price of the composite good  $X$  to be unity. The worker chooses the  $p^*$  (and thus a job-risk combination) that maximizes expected utility  $G$  where:

$$G = (1-p)U(W(p)) + pB(sW(p)).$$

The necessary condition for  $G$  to be maximized is:



$$(1) \quad G_p = (1-p)U'W' + pB'sW' - U + B = 0.$$

Solving for  $W'(p^*)$  yields

$$W'(p^*) = \frac{U - B}{(1-p^*)U' + p^*sB'}$$

Consumers choose a job so that the ratio of the marginal utilities in the two states of nature are proportional to the wage premium. If utility is higher in the state of no injury than in the state of injury,  $W'(p^*) > 0$  and firms must offer higher wages to entice workers to accept more risky jobs. This conclusion holds for risk averse, risk neutral, and risk loving workers alike.<sup>2</sup>

The effect that workmen's compensation has on the observed market determined risk premium  $W'(p)$  can be determined by implicit differentiation of (1). This yields:

$$\frac{\partial p^*}{\partial s} = \frac{-(1+p)B'W'(p)}{G_{pp}} > 0.$$

Thus introducing, or more explicitly, increasing the percentage of market earnings that workmen's compensation payments will recoup in case of injury will induce the worker to accept a job that has attached to it a higher risk of injury. We know that a worker who prefers not to be injured ( $U > B$ ) must be compensated with a higher wage to accept a job with a higher  $p$ . However, it remains to be determined how the risk premium is affected by increased insurance coverage in the form of workmen's compensation payments.

If  $W(p)$  is concave,  $W''(p) < 0$  and  $\frac{\partial p^*}{\partial s} > 0$  imply that the wage premium  $W'(p)$  declines as workmen's compensation increases. The increased

workmen's compensation raises the level of utility in the event of injury. Thus the gap between the utility levels in the separate states of the world is narrowed. The unfortunate event of injury is less "painful", so more risk (and higher income) is now consistent with the same preference function.

But  $W(p)$  is a market equilibrium locus of tangencies of worker indifference curves and firm isoprofit job offer curves. Economic rationale does not necessarily require  $W'(p) < 0$ , and the concavity of  $W(p)$  is not a necessary condition for the uniqueness of  $p^*$ .<sup>3</sup> Thus we cannot unambiguously predict that the wage-risk premium will decline with higher workmen's compensation payments.

However, the model clearly predicts that workers will accept riskier and higher paying jobs with increased workmen's compensation payments, i.e.,  $\frac{\partial p^*}{\partial s} > 0$ . Actual expected workmen's compensation payments are positively correlated with this increased risk for two reasons:

- (1) the probability of injury and therefore, of payment is higher; and
- (2) wages, on which workmen's compensation payments are based, are higher for riskier jobs.

Thus, models of the wage-risk market equilibrium that ignore the impact of insurance or workmen's compensation payments omit an important part of the worker's risk premium calculus. Furthermore, econometric estimates of the risk-compensating wage premium are biased upward if workmen's compensation payments are positively correlated with the independent variable of most interest, risk.

### III. An Estimate of the Impact of Workmen's Compensation Payments On Wage-Risk Premiums

Recall that the  $W(p)$  locus of job opportunities available to each worker is dependent on the worker's productive capacity. Thus human

capital and/or socioeconomic variables are required for an accurate specification of any market wage equation. That is to say,  $W(p,c)$  must be estimated, where  $c$  is a vector of worker and job characteristics. Thaler-Rosen provided a basis for incorporating these variables in a hedonic estimation of wages, thus defining an appropriate method for empirically estimating the value of reducing the risk of death or injury. Apparently because of multicollinearity, they ignored the interaction of risk and socioeconomic variables on job risk premiums.<sup>4</sup> We contend that these interactions are crucial to a correct specification of the  $W(p,c)$  function, because they represent differences in the locus of opportunities available to workers due to differential abilities to work in risky situations and self-selection biases that influence individuals' willingness to work in risky situations. The principle components technique is employed in this study to obviate the problems of multicollinearity inherent in such variables [3, pp. 143-4].

In addition, the model is specified in a manner that measures the impact of workmen's compensation payments on the observed risk-compensating wage premium. To do this we estimated the equation in three forms, two with workmen's compensation payments included and one without. Equation 1, in which workmen's compensation is excluded, was estimated to provide comparability to the Thaler-Rosen estimates. The theory does not result in an exact prediction of the appropriate specification of the equation when workmen's compensation is included. Therefore, two specifications are used. Equation 2 redefines the dependent variable to be the expected wage,  $[(1-p)W + psW]$ . The third equation uses the absolute value of the difference between wages and compensatable losses if an injury should occur,  $W - sW$ . The extremely high

correlation between weekly wage,  $W$ , and the workmen's compensation variable,  $s_k W$  ( $s_k$  is the effective rate of compensation for salary lost in the event of injury in the  $k$ -th state), precluded simply adding  $s_k W$  as an explanatory variable on the RHS because this led to the swamping of all other explanatory influences. Thus we regressed  $W - s_k W$  on the listed explanatory variables as a way of incorporating the effect of workmen's compensation in equation 3. This procedure is econometrically equivalent to assuming the coefficient of  $s_k W$  to be +1 if left on the RHS. It is well known that this procedure leads to unbiased estimates of the other coefficients. Since it is one of these other coefficients, specifically, the coefficient on our risk factor, that we are concerned with, this procedure allows us to estimate the effect of workmen's compensation on wage-risk premiums, our sole intent. Since the estimated coefficients are unbiased in the workmen's compensation equation, they are subject to the standard interpretations.

The measure of wages ( $W$ ) used is the average weekly wage of individuals in a selected group of occupations, the wages taken from the public use samples of the 1970 Census of Population, 1/10,000 sample [8].

The measure of risk ( $p$ ) used is identical to that used by Thaler-Rosen. It is the actuarial risk of death by occupation class provided by the Society of Actuaries [6]. We assume that the probability of serious injury is proportional to the probability of death and that the probabilities are not cumulative.

The effective rate of salary regained or other benefits payable from workmen's compensation ( $s$ ) was taken from the Compendium on Workmen's Compensation [4]. The variable, as calculated by Rosenblum

varies across states and adjusts for various payment techniques, e.g., delay time before a worker is eligible for compensation. Other demographic variables include unemployment rates (UNEMP). This variable was not considered by Thaler-Rosen. However, it should be expected, a priori, that workers will get less disutility from taking on riskier jobs when alternatives are limited by unemployment. We measured unemployment by the percent of the labor force unemployed in the nearest city for which BLS statistics exist.

Thaler-Rosen found union membership to be highly correlated with wage premiums. Presumably, union education programs provide workers with better information about the risk of injury or death related to different occupations. UNION was measured as the percent of each occupational group unionized by industry.<sup>5</sup>

Demographic and personal characteristic variables included are whether or not the worker lives in an SMSA (URBAN), age (AGE), race (WHITE), marital status (MARR), education (years of schooling (EDUC)), whether or not the worker is the head of a family (FH), i.e., the major breadwinner, whether or not the individual held a full time job (FT), and finally, whether the occupation could be classified as operative (OP), service (S), or general labor (GL). The variables that identify factors about the individual (age, education, race, marital status, and family head) were introduced to measure differences in attitudes toward risk across workers. The job characteristics were introduced to further isolate factors that might lead individuals to undertake jobs that encounter higher risks with a lower compensating risk premium, i.e., the self selection problem. Data for these variables were taken from the 1970 Census of Population [8].



The method of principle components was used to correct for multicollinearity. Specifically, three factors with eigen values greater than one were found among the linear estimates of the socioeconomic variables that made up the principle components.<sup>6</sup> Those are labeled SEF1, SEF2, and SEF3. Principle component analysis also was applied to the risk and risk interaction terms. That produced one factor with an eigen value greater than one, labeled RF. Ordinary least squares was then used to estimate the following three equations:

$$(1) \quad W = a_{RF} + b_{UNEMP} + c_{UNION} + d_{URBAN} + e_{NE} + f_{SOUTH} + g_{WEST} + SEF1 \\ + SEF2 + SEF3 + u$$

$$(2) \quad (1-p)W + psW = a_{RF} + b_{UNEMP} + c_{UNION} + d_{URBAN} + e_{NE} + f_{SOUTH} \\ + g_{WEST} + SEF1 + SEF2 + SEF3 + u$$

$$(3) \quad W - sW = a_{RF} + b_{UNEMP} + c_{UNION} + d_{URBAN} + e_{NE} + f_{SOUTH} + g_{WEST} \\ + SEF1 + SEF2 + SEF3 + u$$

Region dummies, NE, SOUTH, and WEST were added as suggested by Thaler-Rosen.

The results of the estimation are shown in Table 1. Our interest centers around the coefficient estimated for the risk variable, RF. RF is estimated as:

$$RF = a_1 p + a_2 (p \cdot AGE) + a_3 (p \cdot MARRIED) + a_4 (p \cdot AGE) + a_5 (p \cdot UNION)$$

where the  $a_i$ ,  $i = 1, \dots, 5$ , are the factor scores from the principle components procedure.<sup>7</sup> Following the procedure outlined by Thaler-Rosen, the estimated value of a 0.001 increase in risk amounts to \$163 per year.

Extrapolating again in the manner of Thaler-Rosen, the value of reducing risk to zero is \$162,575.<sup>8</sup>  $(\frac{\partial w}{\partial p} \times 50 \times 10^{-2} = a(a_1 + a_2 \overline{AGE} + a_3 \overline{MARRIED} + a_4 \overline{WHITE} + a_5 \overline{UNION}) \times 50 \times 10)$  This estimate is very similar to that of Thaler-Rosen. A similar procedure applied to the risk coefficients estimated in equations 2 and 3 provide estimated values of life of \$117,574 and \$125,378, respectively. These estimates reflect declines in the estimated value of life of 27 and 23 percent, respectively. Thus, empirical estimates of the risk compensating wage premium that ignore the effects of insurance schemes may substantially overestimate the value of life.

### Conclusion

We have shown that an attempt to adjust for insurance substantially reduces estimates of value of life. This finding is consistent with the suggestions of Bailey [1]. The results of our empirical analysis should only partially account for the full influence of insurance because only one of many existing forms of insurance is estimated. Therefore, further analysis of market determined estimates of value of life should extend our analysis to other forms of insurance.

Footnotes

<sup>1</sup>The model relies on the work by Ehrlich and Becker [2].

<sup>2</sup>The second order condition is

$$G_{pp} = 2W' \cdot (sB' - U) + (1-p) \cdot U'' \cdot (W')^2 + pB'' \cdot (sW')^2 \\ + W'' \cdot ((1-p)U' + psB') < 0.$$

The  $p^*$  which satisfies equation (1) is unique only if  $G_{pp} < 0$  holds.

<sup>3</sup>If  $G_{pp} < 0$  then  $W'' < \left\{ \frac{1}{(1-p)U' + psB'} \right\} \{ 2W' \cdot (U' - sB') \\ - (1-p)U''[W']^2 - pB''[sW']^2 \}.$

Clearly this permits but does not require  $W'' < 0$ .

<sup>4</sup>With the risk-socioeconomic interactions included, the standard errors of all risk related variables increased dramatically. Risk by itself, however, was no longer significantly related to the dependent variable, the weekly wage rate [7, Table 3, pp. 291-2].

<sup>5</sup>Thaler-Rosen were able to identify whether or not each worker in their sample belonged to a union. Those data were not available to us. Therefore, we use percentage of each occupational group unionized by industry. Not surprisingly, due to the large sample sizes of the two studies, the means do not differ substantially.

<sup>6</sup>Those principle components include age, race, education, family head, full time, operative, service, and labor.

<sup>7</sup>The factor scores and mean values of the variables are:

$a_1 = .431$	$\overline{AGE} = 39.77$
$a_2 = .008$	$\overline{MARRIED} = .994$
$a_3 = .348$	$\overline{WHITE} = .8646$
$a_4 = .363$	$\overline{UNION} = 52.254$
$a_5 = .005$	

<sup>8</sup>Undoubtedly, this linear extrapolation underestimates the true value of life. All occupations for which data are available provide a narrow range of risk levels concentrated at the lower end of the scale. Therefore, it has been impossible in this and other studies to find meaningful non-linear estimates of the risk-wage trade-off.

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Table 1

Regression Estimates of Wage-Risk Premiums  
(Standard Errors are in parentheses)

<u>Dependent Variable</u>	(1) W	(2) (1-p)W + psW	(3) W-sW
<u>Independent Variables</u>			
RF	193.03 (134.67)	140.78 (102.70)	148.86 (79.55)
UNEMPLOYMENT	-1.92 (2.7)	-1.88 (2.68)	-3.71 (1.6)
UNION	0.55 (0.07)	0.55 (0.06)	0.32 (0.04)
URBAN	-17.37 (5.76)	-17.22 (5.72)	-8.04 (3.4)
NE	-18.89 (4.91)	-18.73 (4.87)	-11.06 (2.9)
SOUTH	-34.58 (5.38)	-34.47 (5.33)	-7.89 (3.18)
WEST	6.00 (6.24)	6.02 (6.19)	4.46 (3.69)
SEF1	1227.57 (127.89)	1227.45 (126.99)	689.76 (75.54)
SEF2	170.58 (128.02)	167.19 (127.40)	149.96 (75.62)
SEF3	227.40 (118.24)	281.58 (117.40)	169.24 (69.84)
Intercept	117.14 (12.51)	116.80 (12.42)	68.23 (7.39)
DF	2242	2242	2242
F	33.2	33.35	28.41















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